

federal regulatory and patent policies to its advantage, and so increase the financial worth of their intellectual property. The Genentech model of the business of biotech, with its organizational alliance with big pharmaceutical companies and its relentless focus on intellectual property, became the dominant model for the next generations of biotech entrepreneurs. In sum, *Genentech* provides detailed, engaging and intimate glimpses of the biotech industry's birth and early growth, as well as how it shifted the relationship between science, academia and private enterprise.

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GEORGES CANGUILHEM, *Knowledge of Life*. Translated from the French by Stefanos Geroulanos and Daniela Ginsburg. New York: Fordham University Press, 2008. xx + 202 pp. \$24.00 (pbk). ISBN: 9780823229260.

Georges Canguilhem (1904–1995) was one of the most influential French philosophers of the second half of the twentieth century. He had considerable impact on the intellectual development of an entire generation of thinkers that included the likes of Michel Foucault, Louis Althusser, Jacques Lacan, Pierre Bourdieu and Jacques Derrida. Outside France he is known primarily in association with these authors. However, Canguilhem was first and foremost a historian and philosopher of science—of the life sciences in particular—and in this respect his oeuvre remains almost completely unknown among Anglophone scholars. It is true that Canguilhem's first book, *The Normal and the Pathological* (first published in 1943 and translated in 1978) has become somewhat of a classic in the philosophy of medicine, but his extensive work in the history and philosophy of biology has hardly received any attention beyond French borders. This is partly down to the fact that much of it is yet to be translated into English. Other than his *Ideology and Rationality in the History of the Life Sciences* (translated in 1988 from the 1981 French edition but now regrettably out of print), the only volume available in English was the 1994 anthology *A Vital Rationalist: Selected Writings from Georges Canguilhem*. That is until now. Fordham University Press has done a splendid job in making available to the English-speaking public as an affordable paperback one of Canguilhem's most important contributions to the history and philosophy of biology.

Knowledge of Life is a collection of seven essays written between 1945 and 1962. Each essay presents a detailed epistemological history of a specific biological problem, concept, or idea in order to advance a particular philosophical thesis. The essays are organized under three headings—'method', 'history' and 'philosophy'—but this classification is largely redundant as every essay engages with aspects pertaining to all three. Indeed, Canguilhem's writing is truly exemplary in its seamless integration of deep historical insight and subtle philosophical argumentation, as the following description of each of the essays in *Knowledge of Life* will hopefully illustrate.

In the first essay, 'Experimentation in Animal Biology', Canguilhem reviews the key epistemological lessons that Claude Bernard drew in his seminal *Introduction to Experimental Medicine* of 1865 in order to argue for the autonomy of experimental methods in contemporary biological research. The very subject matter of biology (that is, life itself) imposes a number of methodological constraints that no biologist can ignore without compromising the biological significance of the obtained empirical data. Canguilhem singles out and discusses four characteristic features of living systems that elicit particularly salient methodological restrictions on a biologist's experimental approach. These are specificity, individuality, totality (or wholeness), and irreversibility.

The second essay, 'Cell Theory', is a rich and nuanced reflection on the importance of the history of science for understanding science. It is also a devastating critique of some of the major theses of logical positivism. Using the history of cell theory as a case study, Canguilhem shows that: (a) the history of science cannot be construed as a linear progression that has led us inexorably to the present; (b) it is a mistake to interpret chronological anteriority as a sign of logical inferiority in our evaluations of theories, concepts and research programs; (c) it is not possible to separate the context of discovery from the context of justification; and (d) theories do not actually proceed from observations but from deeply rooted epistemological commitments. With regards to cell theory itself, Canguilhem characterizes the history of its formulation, as well as the endless debates over its tenability, as a dialectical battle between two dichotomous representations of the morphological constitution of the living body: one emphasizing continuity, the other emphasizing discontinuity.

In the third essay, 'Aspects of Vitalism', Canguilhem offers a much-needed reappraisal of the vitalistic tradition in biology. Far from being a mystical doctrine requiring the postulation of enigmatic life forces, history actually shows that the label 'vitalism' is appropriate for any biology that has sought to defend its autonomy from the annexationist ambitions of the physicochemical sciences. Indeed, if there is one thing that all vitalists throughout history have had in common is a commitment to the view that organisms possess distinctive properties that cannot be completely explained in reductionistic terms. But for Canguilhem vitalism is not so much a doctrine as an attitude—an intellectual orientation towards the scientific study of life. This is what explains its resilience through the centuries. To be a vitalist is to recognize the spontaneity and unpredictability of life and consequently demand an epistemology and methodology in biology that does justice to life's distinct character.

The fourth essay, 'Machine and Organism', is a highly original analysis of the relation between organism and machine. Since René Descartes it has become standard practice in biology to think of the structure and function of organisms on the basis of the structure and function of machines. Only rarely has anyone sought to understand the machine on the basis of the organism. This is what Canguilhem sets out to do. His central claim is that technological artifacts are not so much the product of man's intellectual activity as they are a reflection and an extension of man's own behaviour as a living being. The history of technology cannot be divorced from the history of biology because the two have unfolded in a dialectical fashion, each borrowing from the other theoretical principles as well as terminology. Thus, to think philosophically about machines is in a sense already to reflect on the nature of the organisms that produce them.

In the fifth essay, 'The Living and Its Milieu', Canguilhem examines the concept of milieu, tracing the history of its usage and examining its significance in the work of a number of biologists. Canguilhem shows how the different meanings ascribed to the notion of milieu reflect how the understanding of the relation between organism and environment has changed throughout history. Whereas mechanists tended to regard the milieu as an ensemble of external circumstances that determine the constitution and condition the behaviour of the organism, vitalists generally conceived the milieu as a foreign and arduous environment against which the organism must continually struggle in order to stay alive. In contrast to both, twentieth century organicists came to view the milieu as the expression of the activity of the organism—just as the organism reflects the action of the environment. From this perspective, the relation between organism and milieu is one of reciprocal influence; the organism shapes its milieu according to its own norms whilst simultaneously adapting to the milieu's ever changing demands.

In the sixth essay, 'The Normal and the Pathological', Canguilhem revisits the central claims of his influential book of the same title. The concept of 'normal' as it is used in medicine is ambiguous; sometimes it designates a contingent fact derived from statistical sampling, others it designates an essential type that serves as a principle of medical evaluation. Canguilhem argues that the latter conception is inappropriate because if the normal is an ideal then reality always lies outside the normal; there are no normal individuals, only imperfect deviations from the norm. But neither can the normal be determined by simple reference to a statistical mean. In Canguilhem's view, the normal can only be established by comparing the organism to itself, either in identical successive situations or in varied situations. Every organism is a different, but equally valid, instantiation of the normal state. What is normal for one organism may be pathological for another, and consequently the boundary between 'normal' and 'pathological' is only truly intelligible in the context of a single organism; it cannot be generalized across organisms. Moreover, the 'pathological' is not the opposite of the 'normal', as the pathological state is not the absence of norms but the presence of different norms (specifically, norms less conducive to the sustainment of the organism). Thus, 'pathological' is the biological contrary of 'healthy', not the logical contradictory of 'normal'.

The final essay, 'Monstrosity and the Monstrous', traces the history of teratology from Antiquity to the nineteenth century in order to shed light on the significance of monsters for biological theory. Canguilhem argues that the concept of 'monster' is intrinsically tied to the living; there are no mineral monsters or mechanical monsters. Their epistemological value resides in that they serve as a reminder of the contingency and precariousness of the order and stability that we intuitively associate with the living state. As Canguilhem astutely observes, it is monstrosity, not death, which constitutes the more epistemologically useful contrast with the living. Death is the necessary and unconditional termination of life—its successful negation from without. Monstrosity is the accidental and conditional threat to the viability of the living—its attempted negation from within. The importance of studying monsters is that it results in a more accurate and complete picture of the conditions that make the living state possible.

Overall, what strikes the contemporary reader upon reading these essays, besides their remarkable erudition and scholarly depth, is how pertinent they continue to be

half a century after they were written. The epistemological lessons that Canguilhem draws from his detailed excursions into the history of biology resonate strongly with the current philosophy of biology agenda. Moving beyond its traditional concern with evolutionary biology, and with population genetics in particular, Anglophone philosophy of biology is increasingly engaging with areas of biological inquiry specifically concerned with the constitution and organization of living systems. In this context, Canguilhem's organicist plea for the autonomy of biological method as well as biological theory has never been more relevant. Those who decide to pick up *Knowledge of Life* will find the writing dense, the arguments subtle, but the effort extremely worthwhile.

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Philosophical Aspects of Science

M.J. NYE, *Michael Polanyi and His Generation: Origins of the Social Construction of Science*. Chicago: University of Chicago Press, 2011. xxii + 405 pp. \$45.00/£29.00. ISBN 0-226-61063-2.

Already well-known to historians of science, Mary Jo Nye (Professor of History emerita at Oregon State University and recipient of numerous awards, including the History of Science Society's George Sarton Medal for Lifetime Scholarly Achievement) has produced another substantive and enlightening work. The book is composed of eight chapters followed by forty-five pages of endnotes and nearly one thousand references. Nye's thesis is that the sociological turn in the characterization and understanding of the nature of science took place between the two World Wars, a generation prior to Kuhn's *The Structure of Scientific Revolutions*, and that Michael Polanyi serves as a focal point of this turn. As one of the book's endorsers (Dieter Hoffman) notes on the back cover, this is much more than a biography of Polanyi; it is an illuminating analysis of the theory and practice of science during the much of the twentieth century as well as an examination of broad intellectual and social history of the time.

Chapter One ('Scientific Culture in Europe and the Refugee Generation') traces Polanyi's life, coming from a relatively well-off Jewish family, in Hungary, particularly in the inter-war decades, but also following WWII and the anti-émigré attitude of post-War America. The next three chapters ('Germany and Weimar Berlin as the City of Science', 'Origins of a Social Perspective: Doing Physical Chemistry in Weimar Berlin' and 'Chemical Dynamics and Social Dynamics in Berlin and Manchester', respectively) detail Polanyi's scientific career and how it shaped his overall conception of the nature of science. Nye argues that his contrasting experiences in Berlin and Manchester led to his vision of what a scientific research community could and should be. He came to formulate for himself a sense of the social and institutional preconditions necessary for the flourishing of modern science.